INDOOR AIR QUALITY ASSESSMENT

Great Falls Middle School
224 Turnpike Road
Montague, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of the Massachusetts Teachers Association (MTA), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Turners Falls High School/Great Falls Middle School complex, 222-224 Turnpike Road, Montague, MA. On December 17, 2003, Cory Holmes and Sharon Lee, Environmental Analysts for BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment of this building. Concerns about indoor air quality related to construction activity prompted the request.

The Great Falls Middle School (GFMS) is a red brick, L-shaped structure located on the Northwest corner of the Turners Falls High School (TFHS) (Picture 1). The new middle school wing was built as part of the on-going construction/renovation project and was occupied at the time of the assessment. The adjacent high school building was under renovation during the assessment; these renovation activities are discussed in a separate IAQ report for the TFHS. No construction/renovation activities were being conducted in the middle school wing during the BEHA visit. To help reduce construction generated dust, school officials reported that four part-time night cleaners were hired and that changing of ventilation equipment filters is scheduled on a weekly basis or as needed, until the renovation project is completed.

Methods

BEHA staff conducted air tests for carbon dioxide, carbon monoxide, temperature and relative humidity with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds

(TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The GFMS houses approximately 300 students in grades 7 and 8 and has a staff of approximately 40. Tests were taken during normal operations. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in fourteen of twenty-six areas surveyed, indicating inadequate air exchange in a number of areas. Mechanical ventilation is provided by rooftop air-handling units (AHUs) and ducted to classrooms via ceiling-mounted air diffusers (Picture 2). Return air is drawn into a ceiling plenum through grated vents and ducted back to the AHUs (Picture 3). These systems were functioning during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The initial equipment balancing should have occurred after the installation of the new HVAC systems. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix A.

Temperature measurements ranged from 67^{o} F to 73^{o} F, which were below or at the lower end of the range in BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity in the building ranged from 26 to 37 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A few areas had water-damaged ceiling tiles, which can indicate leaks from the roof or plumbing system (Picture 4). Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Several classrooms contained a number of plants. Plant soil and drip pans can serve as a source of mold growth. Plants should be located away from the air stream of ventilation to prevent aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5. Outdoor carbon monoxide concentrations were measured at 0 to 1 ppm (Table 1). Carbon monoxide levels measured in the school generally reflect levels measured outdoors.

Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions of reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (USEPA, 2000). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997).

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. According to the NAAQS established by the USEPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average. *Carbon monoxide should not be present in a typical, indoor environment.* If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average. This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average. Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment. Outdoor PM2.5 concentrations were measured at 117 (Table 1), which exceeded the proposed NAAQS. PM2.5 levels measured in the school reflected outdoor levels, exceeding the proposed NAAQS in a number of areas. No construction related activity was being conducted in the GFMS at the time of the assessment; however, BEHA staff noted strong odors of burning wood most likely related to chimneys, woodstoves and fireplaces from area residences. Atmospheric/weather conditions at the time of the assessment (i.e., fog and rain) also could have influenced airborne pollutant concentrations by limiting dispersion causing these pollutants to be "trapped" in the general area. Where an outdoor source of pollutants has the potential to be introduced into a building via the HVAC systems, steps should be taken to reduce indoor levels below the NAAQS (ASHRAE, 1989). In this instance, an increase in the dust spot efficiency [also called Minimum Efficiency

Report Value (MERV)] of filters installed in the HVAC system may help reduce particles from homes using wood burning stoves from entering the school's indoor environment.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were measured non-detect or ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

While no TVOC levels measured in the indoor air exceeded background levels, materials containing VOCs were present in the school. Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Also of note was the amount of materials stored in some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Complaints of dust accumulation in radiator fins were reported in room M-214. Dust can be irritating to eyes, nose and respiratory tract.

Finally, in an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 5). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and to off-gas VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Operate both supply and exhaust ventilation continuously during periods of school occupancy independent of classroom thermostat control to maximize air exchange. Consult the school's heating, ventilation and air conditioning (HVAC) engineer concerning an increase in the introduction of outside air.
2. Examine the feasibility of installing more efficient filters in AHUs to reduce airborne particle levels. Contact the manufacture of FCUs or HVAC engineering firm to determine appropriate size and installation of filters.
3. Consult the school's ventilation engineer concerning balancing of the ventilation systems. SMACNA recommends that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

4. Develop a clear line of communication between the central maintenance department and school personnel for prompt remediation of temperature and/or ventilation concerns/complaints. This can be done by establishing a written request system administered by a single responsible person. Classroom occupants should report temperature extremes immediately to school administration/maintenance.
5. Consider installing high efficiency and/or a charcoal filter medium to minimize entrainment of wood stove odors and particulates.
6. Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Ensure plants are equipped with drip pans. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
8. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning.
9. Vacuum radiator fins in classroom M-214 with a HEPA-filtered vacuum.
10. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.
11. Consider adopting the US EPA document, "Tools for Schools" as a method for maintaining a good indoor air quality environment. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

12. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

ASHRAE. 1989. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 62-1989

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL.

MDPH. 1997. Requirements to Maintain Air Quality in Indoor Skating Rinks (State Sanitary Code, Chapter XI). 105 CMR 675.000. Massachusetts Department of Public Health, Boston, MA.

NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.

NIOSH. 1998. *Latex Allergy: A Prevention Guide*. National Institute for Occupational Safety and Health, Atlanta, GA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.

SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC. Http://www.sbaa.org/html/sbaa_mlatex.html

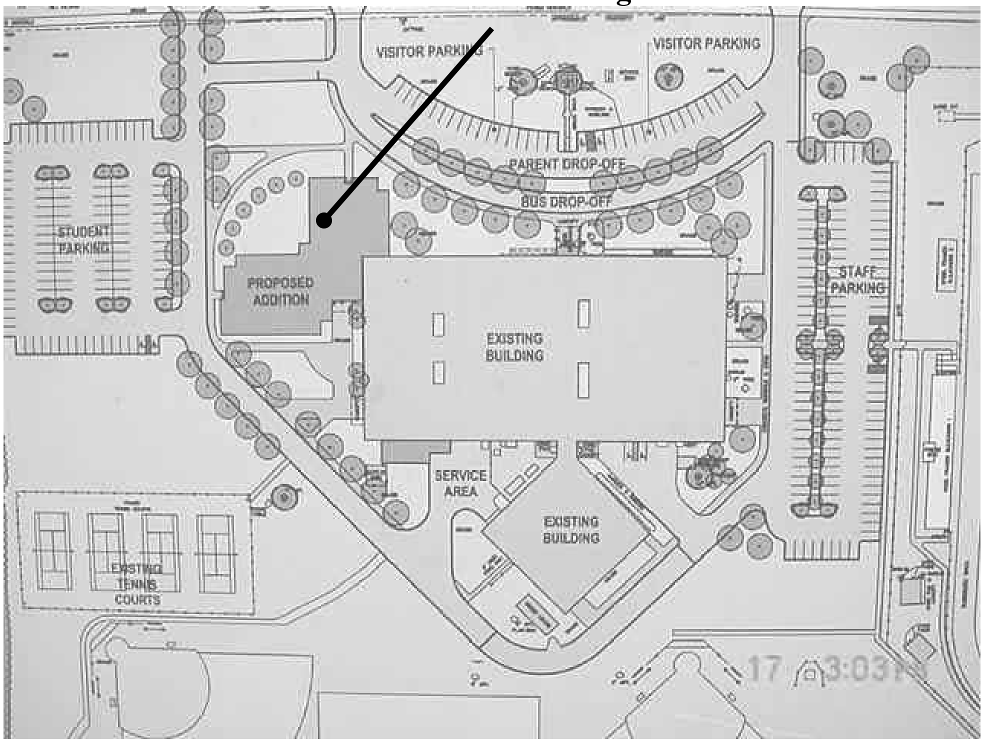
SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

USEPA. 2000. National Ambient Air Quality Standards (NAAQS). . US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

Picture 1

Middle School Wing



Plans for Turners Falls High School/Great Falls Middle School Construction/Renovation Project

Picture 2

Ceiling-Mounted Air Diffuser

Picture 3

Ceiling-Mounted Return Vent

Picture 4

Water-Damaged Ceiling Tiles

Picture 5

Tennis Balls on Chair Legs

Great Falls Middle School | **Indoor Air Results**

224 Turnpike Road, Montegue, MA | **December 17, 2003**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	56	41	352	0-1	ND	117		-	-	-	Strong wood stove odors, parking lot in front of building, moderate traffic, moderate rainfall/sleet, foggy conditions
M 234	67	37	590	0-1	ND	57	2	N	Y	Y	Plants, heat concerns (no openable windows), DEM, DO
M 213/211	70	29	514	1	ND	63	3	Y	Y	Y	Dusty-unpacking books to relocate to library
M 210	70	31	795	0-1	ND	68	20	Y	Y	Y	Noise complaints-HVAC system, DEM
M 212	70	29	462	0-1	ND	59	0	Y	Y	Y	DEM, plants, DO
M 207	70	31	874	1	ND	66	19	Y	Y	Y	DEM, PF, flammable materiels (lantern fluid) on floor
M 205	70	32	763	ND	ND	55	14	Y	Y	Y	DEM

ppm = parts per million parts of air
µg/m3 = microgram per cubic meter

AD = air deodorizer
AP = air purifier

CD = chalk dust
DEM = dry erase marker
DO = door open
ND = non detect
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
UV = univent

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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									Supply	Exhaust	
M 204	70	33	858	0-1	ND	60	18	Y	Y	Y	Window open, DEM
Hallway outside M 204											2 water damaged CTs
M 104	70	29	782	ND	ND	53	0	Y	Y	Y	DEM, TB, photocopier, personal fan
M 105	70	29	634	ND	ND	53	0	Y	Y	Y	DEM, TB,
M 106	69	34	438	ND	ND	53	18	Y	Y	Y	DEM, TB
M 107	70	30	746	ND	ND	56	20	Y	Y	Y	DEM, CD, cleaning products, plants, TB
M 109	69	31	1039	ND	ND	61	2	Y	Y	Y	DEM, clutter, dust/dirt acuumulation-flat surfaces

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M 110	69	31	1048	ND	ND	74	19	Y	Y	Y	Complaints of itchy eyes, DEM, clutter, window open
M 111	69	30	848	ND	ND	60	0	Y	Y	Y	DEM, TB
M 112	70	31	896	ND	ND	60	1	Y	Y	Y	PF, DEM, food storage/use
M 114	69	30	940	ND	ND	47	3	N	Y	N	DO, TB, DEM, plants, PF, CD, odor complaints
M 113	70	34	1333	ND	ND	62	15	Y	Y	Y	DEM, TB, pencil shavings
Cafeteria	69	26	529	ND	ND	44	10	Y	Y	Y	Slight burning odor (kitchen),,AC, DEM, CD
Main Office	70	31	1055	ND	ND	45	1	N	Y	N	DO

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Afterschool Office	71	29	1082	ND	ND	43	0	Y	Y		DO, acuumulated items
Copy Room	73	29	1079	ND	ND	39	0	N	Y	Y	Photocpiers, DO
Principal's Office	72	29	1211	ND	ND	43	1	Y	Y	Y	No draw exhaust vent, coffee odors
M 206	70	34	1301	ND	ND	56	19		Y	Y	MT outside of M 206 (hallway), DEM, plants, PF
Conference Room	70	31	1007	1	ND	46	0	Y	Y	Y	
M 214	71	30	590	1	ND	56	2	N	Y	Y	DO, dust complaints-radiator
M 201	71	30	793	1	ND	65	27	Y	Y	Y	TB, DEM

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